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PURE CORROSIVE MODEL OF THE DEVELOPMENT OF VERTICAL KARST-SHAFTS

In the northern part of Hungary some outcrops of Triassic limes-stones have brought about extended karstic regions. On the plateaus of these mountains many dolinas and many vertical shafts /in Hungarian: "zsomboly"/ are to be found. In many cases the entrances of these shafts are situated on the upper part of the dolina-slope. The entrances are very narrow when compared with the depth.

It is characteristic that these shafts are frequent in small areas. For instance on the "Alsóhegy"-plateau in Northern-Hungary more than 50 shafts are known in an area of 12 km² extent, seemingly in irregular distribution.

It is difficult to explain the abundance of the cavities supposing that they are independent fossil swallow-holes. That is why we tried to explain their origin with an actually working effect /Principle of Actuality/. According to our hypothesis the vertical shafts have to come into existence on certain conditions which are recently wide-spread too.

Thus the karst-shaft is one of the general karst-phenomenas.

Items of the teory

A./ The shafts /as the dolinas/ have a corrosive origin.
B./ The shaft starts to develop on the deepest point of the dolina.
C./ The cavern of the shaft develops downwards.
D./ During the process the deepest part of the dolina changes its place.
E./ The precipitation infiltrating on the surface of the dolina is sufficient to dissolve the lacking rock-mase. It is not necessary to suppose bigger catchment area.

The items are successively discussed.

A./ The corrosive origin of the vertical shafts

According to the wide-spread opinion /Moravetz 1965/ the dolinas have their origin due to corrosive processes. This process is taking place at a shallow zone under the bottom of the sinking, along the openings and on the rock surface. This sinking acts as a trap for the snow and for the organic matters /Terzaghi 1912, Geze 1965/, consequently the precipitation infiltrating on its surface is higher than the average and this precipitation gains more carbon-dioxide than the average from the soil and leaf-litter deposit. Consequently the thickness of the corrosive zone in only about a few metres.

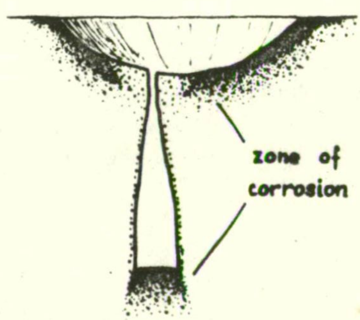


Fig. 1.

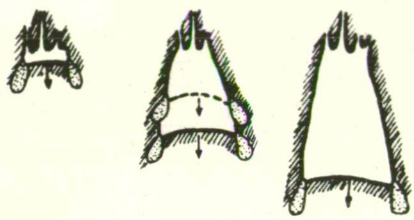
The water percolating through this zone is practically saturated with hydrocarbonates. Where the zone of corrosion is crossed by a fissure or joint, a discontinuity arises. The water runs down quickly to the bottom of the fracture. The drain-effect tends to accumulate water from the surrounding. The humus deposit at the bottom of the fissure intensifies the effect of corrosion.
Consequently the shaft is a discontinuity in the corrosion-zone of the dolina, where a part of the zone gets down to a lower level /Fig. 1./. The bottom of the shaft is sinking by corrosion.

B./ <u>The shaft starts to develop on the deepest point of the dolina</u>

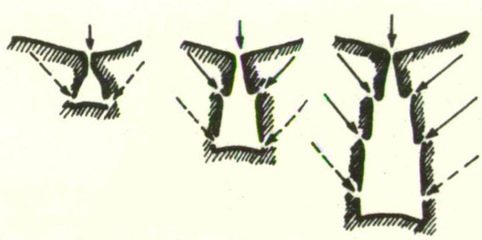
According to the potentialities, several shafts may start to sink simultaneously in the same dolina. The hole situated in the very bottom of the dolina exerts a drain-effect to the other holes, and their development thus is restrained. So the hole at the deepest pont has the biggest catchment area.

C./ <u>The cavern of the shaft develops downwards</u>

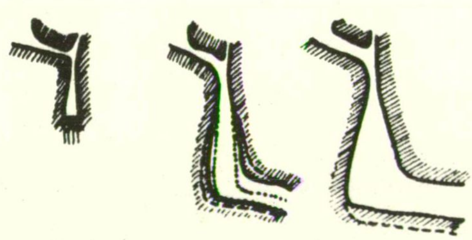
The water running down on the wall of the shaft has no time enough to become fully saturated. It can dissolve rock material mostly at places where it slows down. Therefore the corrosion is taking place chiefly near the bottom of the cavity. This part turns into the now corrosion-zone. In this zone the water becomes practically saturated and percolates down without enlarging the lythoclases. Though the water flowing down on the walls makes the cavern more spacious, the growing is chiefly the result of the deeping. The drain-effect and the erosion-effect grows with the dept, and this contributes to the shaping of the sugar-loaf-like form of the shaft /Fig. 2./.



a.) zone of corrosion is near to the walls



b.) quantity of water increases in function of the depth



c.) effect of erosion increases in function of the depth

Fig. 2.

D./ <u>During the process the deepest part of the dolina changes its place</u>

The shaft itself drains the water from its vicinity. In this surrounding the water leaves unsaturated the corrosion-zone of the dolina. This is the reason that this part of the dolina's bottom can not sink as fast as the other parts. Because of the slower development in the central part, one of the slopes of the dolina overpasses in sinking the former deepest part. So the very bottom of the dolina changes its place. This new place provides an opportunity for a new shaft to develop.

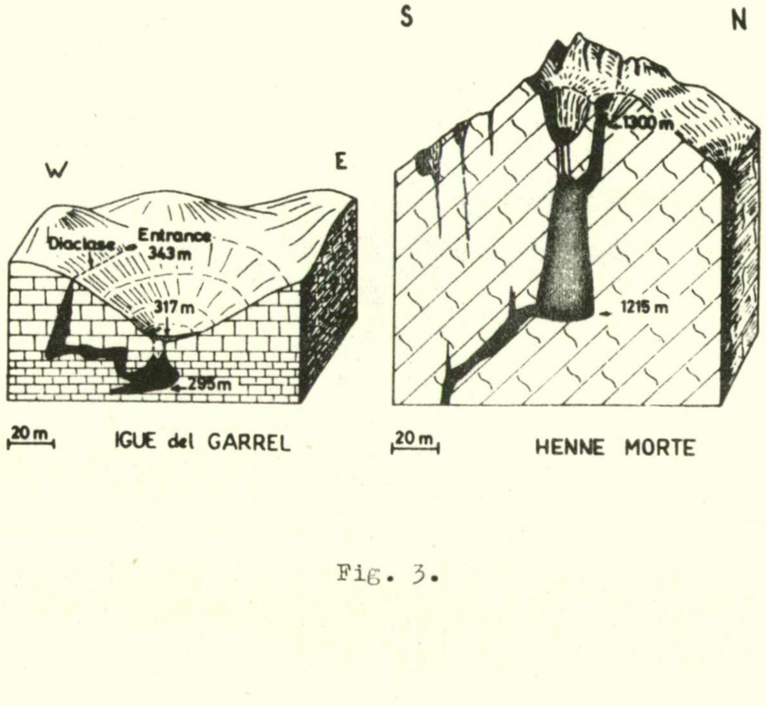


Fig. 3.

With the translocation of the centrum of the mother-dolina the entrance of the first shaft comes to the slope of the dolina. This trend of progress explains clearly: why even in homogeneous rocks the karst shafts have a step-like structure. This process seems to be probable in the case of some well-know karst-shafts /Fig. 3./.

E./ <u>The precipitation infiltrating on the surface of the dolina is sufficient to dissolve the lacking rock-mass</u>.

We should like to demonstrate that the recent natural factors are able to produce karst-shafts. For the sake of illustration we use data of the shafts in the "Alsóhegy" karst-plateau in Northern-Hungary.

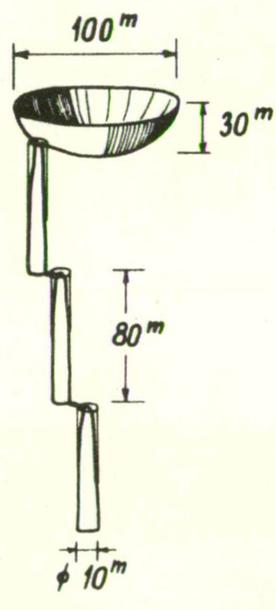


Fig. 4.

The simplified data are as follows:

Elevation of the plateau:	500 m above sea level
Elevation of the springs:	200 m above sea level
Average diameter of dolinas:	100 m
Average yearly precipitation:	700 m
Average Ca-ion concentration of the spring-water:	100 milligrams pro litre

The karstification is supposed to have its beginning in the Early Plaistocene, about two million years ago.

The deepest known karst-shafts attain nearly the level of the springs. The horizontal cross-sectional area of them is moderate: two or four times 10 m^2.

Starting from these data an average dolina-shaft system has the following dimensions /calculating that the dolina is a spherical section, and the shaft is a cylinder, Fig. 4./.

Horizontal surface of the dolina:	S_d /m^2/ = 7,85 . 10^3
Volume of dolina:	V_d /m^3/ = 1,32 . 10^5
Volume of shaft:	V_s /m^3/ = 1,88 . 10^4
The system's lack of mass:	$V_d + V_s$ /m^3/ = 1,50 . 10^5

It is noticeable that the volume of the dolina surpasses the volume of the shaft with one order of magnitude.

The 100 milligrams Ca in the spring-water is equivalent with 250 milligrams $CaCO_3$. That means that every m^3 of the spring-water contains 250 gramm dissolved rock-mass. As the specific wight of the rock is about 2,5 the volume--ration betwen the water and the dissolved rock-material is:

$$R = 1/10.000 = 10^{-4}$$

Supposing that the increasing of the dolina-surfaces in linear, and integrating the instant dolina-surfaces /Fig. 5./:

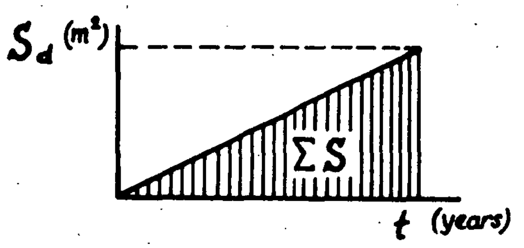


Fig. 5.

$$S = S_d \cdot t/2 = 7,85 \cdot 10^9 \ /m^2/$$

In only 200 mm water infiltrates yearly from the 700 mm precipitation on this surface, thus the total dissolving water-volume is:

$$W = 1,57 \cdot 10^9 \ /m^3/$$

The calculated lack of mass according to this water-volume is:

$$V_c = W \cdot R = 1{,}57 \cdot 10^5 \ /m^3/$$

So

$$V_c \approx V_d + V_s$$

that means that the calculated lack of mass is near to the real volume of the average dolina-shaft systems.

In the calculation we neglected several factors: the volume of shaft was supposed to be bigger than the actual, the infiltration seems to be higher than 200 mm/ /year, etc.

Summary

According to our hypothesis, the sinking shaft acts as a drain of its own dolina, and as a result their origin and development is common.

We try to outline the origin of the shafts as follows:

Before the rising, the surface of the karstic massive becomes flat by erosion. According to some new theories /Aubert, 1969/ the karstic plateau can develop after the rising of the massive, too. When arising, subvertical lithoclases can come into existence in the massive. On the favourable spots begins the development of dolinas. /Fig. 6/1/ The lithoclases at the bottom of the dolina make the zone of corrosion discontinuous; in this places the zone of corrosion sinks to a lower level /Fig. 6/2/.

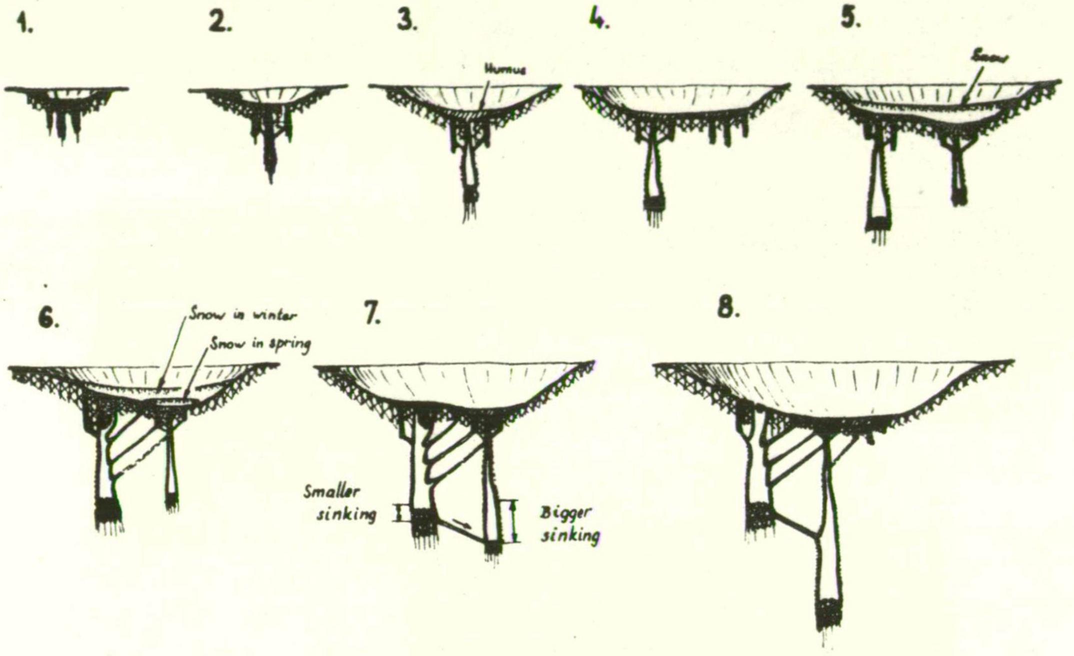


Fig. 6.

The sinking shaft drains the water from the dolina. For this reason the sinking of the dolina-bottom slows down in the vicinity of the shaft. /Fig. 6/3-4/. So the deepest point of the dolina necessarily changes its place, and under the new bottom a new shaft begins to develop. /Fig. 6/5./

The water of the second shaft is drained partially by the first cavity. In spite of this the deepening of the second cavity shall be more rapid as the base-area available for dissolution is smaller, the catchment-area is bigger, then in the case of the first cavity, and because of the accumulated snow and leaf-litter in the bottom of the dolina. /Fig. 6/6-7./ Therefore the new shaft overpasses in sinking the bottom of the first cavity, drains it and from this time on the new shaft sinks faster. /Fig. 6/8./

The water runs down on the walls of the developing shaft. At the foot of the wall the water dissolves the rock downwards and laterally. This is one of the reasons of the widening. Reaching 10-15 metres of depth, the erosion will fortify this effect. The rock-fragments, made by erosion can not leave the cavity through the lithoclases but accumulate and later it will be dissolved. So the cave is not increased /only shaped/ by erosion.

The development follows until the shaft reaches the base-level. Arriving at this level the primary dissolvent water begins to widen a horizontal cavity. In a permanently rising karst, thus in the case of sinking base-level, there is a low probability of the development of a passable horizontal cave originating from the shaft. If the rising stops, or if the base-level rises together with the plateau, the result of the process could be an important horizontal cave.

The authors believe this model of development to have a general validity. Anyway, in any individual case the applicability of this theory must to be investigated.

TEXT OF FIGURES

R E F E R E N C E S

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